Station Bulletin 226 February, 1927

Oregon Agricultural College

Experiment Station

A Progress Report on the Removal of Spray Residue from Apples and Pears

By

R. H. Robinson

and

Henry Hartman

CORVALLIS, OREGON

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION

Hon. J. K. Weatherford, President	Albany
Hon. E. E. Wilson, Secretary	Corvallis
Hon. B. F. Irvine, Treasurer	Portland
Hon. Walter M. Pierce, Governor	Salem
Hon. Sam A. Kozer, Secretary of State	Salem
Hon. R. R. Turner, Superintendent of Public Instruction	Salem
Hon. George A. Palmiter, Master of State Grange	Hood River
Hon. Mrs. W. S. Kinney	Astoria
Hon. Sam H. Brown	Gervais
Hon. Harry Bailey	Lakeview
Hon. Geo. M. Cornwall	Portland
Hon. E. B. Aldrich	Pendleton
Hon. Jefferson Myers	Portland

STATION STAFF

W. J. Kerr, D.Sc., LL.D.	President
J. T. Jardine, B.S.	Director
E. T. Reed, B.S., A.B.	Editor
H. P. Barss, A.B., S.M.	Plant Pathologist
F. D. Bailey, M.S.	Asst. Pathologist, Insecticide and Fungicide Bd., U. S. Dept. of Agri.
B. B. Bayles	Junior Agronomist, Office of Cer. Inves., U. S. Dept. of Agri.
R. S. Besse, M.S.	Associate in Farm Management
P. M. Brandt, B.S., A.M.	Dairy Husbandman
A. G. Bouquet, B.S.	Horticulturist (Vegetable Gardening)
E. N. Bressman, B.S.	Associate Agronomist
G. G. Brown, B.S.	Horticulturist, Hood River Br. Exp. Station, Hood River
W. S. Brown, A.B., M.S.	Horticulturist in Charge
D. E. Bullis, B.S.	Assistant Chemist
A. S. Burrier, M.S.	Assistant in Farm Management
Leroy Childs, A.B.	Supt. Hood River Branch Exp. Station, Hood River
G. V. Copson, M.S.	Bacteriologist
H. K. Dean, B.S.	Supt. Umatilla Branch Exp. Station, Hermiston
C. R. Donham, D.V.M.	Assistant Veterinarian
Theo. P. Dykstra, M.S.	Assistant Plant Pathologist, U. S. Dept. of Agri.
E. M. Edwards, B.S.	Asst. Animal Husbandman, East Ore. Br. Exp. Sta., Union
A. E. Engbretson, B.S.	Supt. John Jacob Astor Br. Exp. Station, Astoria
L. N. Goodding, B.A., B.S.	Jr. Plant Pathologist, U. S. Dept. of Agri.
W. V. Halversen, Ph.D.	Associate Bacteriologist
H. Hartman, M.S.	Associate Horticulturist (Pomology)
E. M. Harvey, Ph.D.	Horticulturist (Physiology)
Bertha C. Hite, B.A.	Scientific Assistant Seed Lab., U. S. Dept. of Agri. (Seed Analyst)
R. E. Hutchinson, B.S.	Asst. to Supt. of Harney Valley Branch Exp. Station, Burns
G. R. Hyslop, B. S.	Agronomist
W. T. Johnson, D.V.M.	Poultry Pathologist
I. R. Jones, Ph.D.	Associate Dairy Husbandman
J. S. Jones, M.S.	Chemist
G. W. Kable, M.S.	Agricultural Engineer
F. L. Knowlton, B.S.	Poultry Husbandman
A. G. Lunn, B.S.	Poultry Husbandman in Charge
M. B. McKay, M.S.	Plant Pathologist
H. G. Miller, Ph.D.	Chemist
G. A. Mitchell, B.S.	Asst. to Supt. of Sherman County Branch Exp. Station, Moro
Don C. Mote, M.S.	Entomologist
O. M. Nelson, B.S.	Animal Husbandman
R. K. Norris, B.S.	Assistant to Supt. of Southern Oregon Branch Exp. Station, Talent
A. W. Oliver, B.S.	Assistant Animal Husbandman
E. L. Potter, M.S.	Animal Husbandman
W. L. Powers, M.S.	Chief, Department of Soils
F. C. Reimer, M.S.	Supt. Southern Oregon Br. Exp. Station, Talent
R. H. Robinson, A.B., M.S.	Chemist
C. C. Ruth, M.S.	Associate Agronomist
C. V. Ruzek, B.S.	Associate in Soils (Fertility)
H. A. Schoth, M.S.	Asst. Agronomist, Forage Crops Investigation, U. S. Dept. of Agri.
C. E. Schuster, M.S.	Associate Horticulturist (Pomology)
H. D. Scudder, B.S.	Chief in Farm Management
H. E. Selby, B.S.	Associate in Farm Management
O. Shattuck, M.S.	Supt. Harney Valley Branch Exp. Station, Burns
J. N. Shaw, D.V.M.	Assistant Veterinarian
J. E. Simmons, M.S.	Assistant Bacteriologist
B. T. Simms, D.V.M.	Veterinarian
D. E. Stephens, B.S.	Supt. Sherman County Br. Exp. Station, Moro
R. E. Stephenson, Ph.D.	Associate Soils Specialist
B. G. Thompson, M.S.	Assistant Entomologist
E. F. Torgerson, B.S.	Assistant in Soils (Soil Survey)
E. H. Wiegand, B.S.	Horticulturist (Horticultural Products)
Joseph Wilcox, B.S.	Assistant in Entomology
Maud Wilson, B.S.	Home Economist
Robt. Withycombe, B.S.	Supt. Eastern Ore. Branch Exp. Station, Union
W. W. Yates, B.S.	Assistant Chemist
S. M. Zeller, Ph.D.	Plant Pathologist

CONTENTS

SUMMARY

(1) The removal of spray residue by wiping and brushing has not been entirely satisfactory. No form of mechanical cleansing thus far tested out has proved effective under all conditions.

(2) Mechanical cleansing has resulted in more or less injury to the fruit.

(3) Mechanical cleaning devices, in some cases, may also aid in the spread of decay organisms.

(4) Experiments with solvents have shown that certain acids and bases will remove spray residue in varying degrees of effectiveness.

(5) It is apparent, however, that only a comparatively few compounds offer possibility from a practical standpoint, and that under no condition can any solvent be used until an adequate storage test has demonstrated that no injury to the fruit results from its use.

(6) Of the many compounds tested, none has proved to be superior to hydrochloric acid. This acid was found to be effective in removing not only arsenicals, but also such forms of residue as lead, copper and lime.

(7) Hydrochloric acid has proved to be practically non-injurious to the fruit when properly used.

(8) Other acids such as nitric, acetic, and sulfuric, while promising in some respects, have generally proved to be inferior to hydrochloric acid.

(9) Although bases in general tend to remove spray residue, sodium hydroxide is the only basic compound discovered that successfully removed arsenate of lead under all conditions.

(10) While this compound offers some possibility, it has proved to be generally less desirable than hydrochloric acid. When used at ordinary temperatures and at the same concentrations, sodium hydroxide has been no more efficient than hydrochloric acid in the removal of arsenate of lead and has been ineffective in the removal of copper and lime.

(11) The use of sodium hydroxide has resulted in more or less injury to the storage quality of the fruit.

(12) The efficiency of solvents is affected by several factors, chief among which are: (1) the length of the treatment, (2) the concentration of the solution, (3) the temperature of the solution, (4) the maturity of the fruit, (5) the amount of agitation given, and (6) the spray program that has been followed.

(13) The use of oil sprays along with the arsenate of lead apparently retards the action of the solvents, but does not make cleaning by this method impossible, provided a sufficient amount of time elapses between the date of application of the oil and the date of treatment.

(14) The use of "spreaders" or "deflocculants" apparently does not interfere materially with the action of the solvents.

(15) It appears that any brand of arsenate of lead used as a spray can be effectively removed by the hydrochloric acid treatment.

(16) The possibility of using a disinfectant along with the solvents is being investigated by the Oregon Experiment Station.

(17) Fruit packed at various stages of wetness following the washing treatment has given varying results. A small amount of moisture appeared to do no harm in cases where the fruit to begin with was comparatively free from contamination and decay.

A Progress Report on the Removal of Spray Residue from Apples and Pears

By

R. H. Robinson

and

Henry Hartman

INTRODUCTION

Owing to the many inquiries that are being received regarding the removal of spray residue, it is thought opportune to report briefly the observations made by the Oregon Experiment Station. It must be borne in mind, however, that many questions regarding this subject cannot be fully answered at this time. Additional work must be done before it can be said that the spray residue problem has been entirely solved. The present paper, therefore, is merely a progress report, published so that the industry may profit during the coming season by the results thus far obtained. The authors are mindful of the fact that subsequent research and practical experience may alter in many details the conclusions drawn from the data now available.

Acknowledgments. The authors have been assisted in the course of these studies by other members of the Station staff, including Leroy Childs, R. K. Norris, S. M. Zeller, W. S. Brown, F. C. Reimer, and R. A. Osborn. They have also received valuable assistance from such organizations and individuals as the Fruit Growers League, Southern Oregon Sales Inc., Denny and Co., Scobel and Day, Rosenberg Bros., the Medford Precooling and Storage Company of Medford, and the Hood River Apple Growers Association of Hood River.

Scope of work. Although many phases of the spray residue problem have been considered, most of the work done by the Oregon Experiment Station has been along two major lines as follows:

(1) A study of various means for the removal of spray residue from apples and pears.

(2) A study of the effects of these means upon the fruit itself.

EXPERIMENTAL

REMOVAL OF SPRAY RESIDUE

Mechanical means. In the course of these studies, considerable attention was given to the mechanical or physical means of removing spray residue, such as hand wiping, machine wiping, and brushing. Results in

this case were obtained from laboratory tests and from field observations in the various apple and pear districts of the state. Consideration was given to the various types of wipers and brushers employed during the season. Results on the efficiency of these devices are based upon visibility tests and upon several hundred chemical analyses on both treated and untreated fruit.

Solvents or "washes." Experiments with solvents or "washes" for the removal of spray residue were started by the Oregon Experiment Station in April, 1926, and have been continuous since that time. The list of compounds tried includes all acids, bases, and salts that were thought to offer possibility. Table I gives a partial list of the chemicals tried. These were tried not only for their solvent action upon arsenicals, but also for their action on such other forms of residue as lead, copper, and lime. The more promising ones were tried at temperatures varying between 35° F. and 95° F. They were also tried at various concentrations and for periods of time varying between 10 seconds and 20 minutes. They were tried on fruit of varying stages of maturity and with varying amounts of agitation. They were tried on fruit which had received various amounts and kinds of sprays during the season. Observations were based not only upon laboratory tests, but upon fruit treated in different ways where solvents were being used commercially. More than 500 chemical analyses have already been made in connection with this phase of the work. Tables III to XI inclusive give a portion of the data obtained relating to the efficiency of solvents used under varying conditions.

METHODS OF ANALYSES

TABLE I. PARTIAL LIST OF CHEMICALS TESTED FOR SOLVENT ACTION ON SPRAY RESIDUE

Inorganic Acids	Bases	Organic Acids	Miscellaneous	Salts
Hydrochloric	Sodium hydroxide	Malic	Cane sugar	Sodium chloride
Nitric	Potassium hydroxide	Citric	Glucose	Potassium chloride
Sulfuric	Sodium carbonate	Tartaric	Alcohol	Sodium thiosulfate
Sulfurous	Sodium bicarbonate	Acetic	Sodium stearate	Ammonium chloride
Phosphoric	Calcium hydroxide	Oxalic	Sodium oleate	Sodium borate
Boric	Ammonium hydroxide	Tannic	Miscible oils	Copper sulfate
	Soda lime	Carbonic	Potassium benzo sulfate	Calcium sulfate
				Sodium chromate
				Sodium acetate
				Sodium nitrate
				Calcium acid phosphate
				Calcium chloride

Determination of arsenic. For the determination of arsenic, one of three procedures was followed depending upon the apparent amount of residue present and upon the condition of the fruit. (1) Where .03 grain or more of arsenous oxide per pound of fruit was present, the residue was dissolved by immersing and agitating the fruit in hot 10-percent nitric acid and finally washing it well under a jet of hot acid. The nitric acid was then driven off by evaporation with sulfuric acid. All

traces of the former were removed by repeated evaporations after the addition of water to the sulfuric acid. The arsenic was then determined by titration with .01 N iodine solution after reduction with potassium iodide. (2) Where about .02 grain or less of arsenous oxide was present, the residue was removed by dissolving in hot 3-percent hydrochloric acid, the amount of arsenic being determined by the Gutzeit method. (3) If the fruit had received an oil spray or an excessive amount of wax had formed on the surface, the fruit was peeled and after the oxidation of the peelings with sulfuric and nitric acids, the arsenic was determined by the Gutzeit method as in case two. This procedure was also employed to test the accuracy of the other methods used.

Determination of lead. Lead was determined as follows: About two pounds of apples or pears were peeled and the peelings were oxidized with sulfuric and nitric acids. The nitric acid was then removed and the lead precipitated as sulfate in 80-percent alcohol. The lead sulfate was finally redissolved in ammoniacal ammonium acetate and determined as chromate.

Copper and lime. Since bordeaux dissolves easily in nitric acid, the latter was used to obtain the copper and lime in solution. The copper was then determined by titration with standard sodium thiosulfate after the removal of the free nitric acid. The lime was precipitated as the oxalate from the same solution after acidifying with acetic acid.

Determination of wax. Although a very accurate determination of the wax on the fresh fruit could not be made, the error was considerably less than the error of sampling. Care was exercised to select practically the same sized fruit in order to obtain equivalent surface areas in the lots to be compared. The wax was extracted with petroleum ether, using repeatedly small portions to dissolve the wax from the surface. For each lot of six specimens about 350 c.c. of ether was used. Continued extraction after using this amount showed that practically all the surface wax had been removed. The petroleum ether was then distilled off and the wax weighed.

Chemical results reported as grains per pound. It will be observed from the tables that the results from chemical analyses are reported as grains per pound of fruit. Arsenic, for example, is reported as grains of arsenous oxide (As_2O_3), lead as grains of lead oxide (PbO), copper as grains of copper (Cu), and lime as grains of calcium oxide (CaO). The apothecaries' system is used instead of the metric system for the reason that the United Kingdom in establishing its tolerance on arsenic has used the grain unit instead of the gram unit, and United States officials, as well as the fruit industry, have generally followed the precedent of Great Britain.

Error due to variation in samples. It is very evident from the experiences of the past season that there are wide variations in the amount of spray residue present on individual fruits, even when they have received the same spray treatment during the season. Analysis of two lots of fruit from the same tree, for example, may show .06 grain of arsenous oxide per pound in one case and .09 grain per pound in the other. This fact must be taken into account in interpreting the results

from chemical analyses. In the present study, a great deal of care was exercised in selecting the lots for analysis, especially when comparisons of the results were to be made. The specimens selected, so far as possible, were of the same size and showed about the same amount of visible residue.

STORAGE TESTS

On August 17, 1926, experiments were undertaken to determine the effects of various cleansing treatments on the dessert and storage quality and also upon the appearance of the fruit. These experiments were later enlarged so as to include fruit from many fruit-growing sections of the state. Up to the present time, more than 700 lots of fruit have been under observation in cold, common, and car storage. Adequate checks were kept in each case so that reliable comparisons could be made. Twenty-four of the leading commercial varieties of apples and seventeen varieties of pears were included in these tests. Aside from the above experimental lots, the Station has had opportunity to observe the effects of both mechanical and chemical cleansing methods on a goodly portion of the fruit commercially treated during the past season. This included about 1000 cars of apples and pears treated with solvents.

Experiments with fruit mechanically treated. Observations, in the case of fruit treated by mechanical devices, were confined largely to the effects of wiping and brushing on loss of weight, shriveling, and breakdown in storage. Tables XII and XIII show the effects of hand wiping on loss of weight in apples.

TABLE II. VARIETIES INCLUDED IN STORAGE TESTS

Apples		
Yellow Newtown	Red Cheek Pippin	Wisconsin Russet
Spitzenburg	Rome Beauty	Golden Delicious
Jonathan	Winesap	Black Twig
Grimes	Akin	Northwestern Greening
Arkansas Black	King David	Wagener
Ortley	Yellow Bellflower	Rambo
Delicious	Winter Banana	Missouri Pippin
Rhode Island Greening	Lawry	Stayman Winesap
Pears		
Bartlett	Lincoln	Winter Bartlett
Comice	Seckel	Diehl
Bosc	Sheldon	d'Anjou
Winter Nelis	White Doyenne	d'Angouleme
Flemish Beauty	Clairgeau	Baronne de Mello
Hardy	Louise bon de Jersey	

Experiments with fruit chemically treated. The storage tests to determine the effects of solvents on the fruit included apples and pears treated with acids, bases, and salts, at various concentrations, various temperatures, and for varying periods of time. Observations were made to ascertain not only the immediate effects of the solvents, but also their effect on the storage and dessert quality, and upon the appearance of the fruit at prime condition when ready for consumption. Tests were also made to determine the effects of solvents upon the wax or protective covering of the fruit. Table XIV shows the effect of hydrochloric acid (HCl) and sodium hydroxide (NaOH) on the wax content of apples and

pears. The fruit used in these tests covered the entire range of maturity Some of it was treated when considerably immature and some was treated at prime condition after full wax development had taken place.

To ascertain the amount of rinsing that needs to be done following the use of solvents, the many lots of fruit employed in these tests were subjected to various treatments. In some cases the fruit was merely rinsed with water while in other cases a neutralizing bath was used. When neutralization was employed following the acid treatments, the fruit was passed through a sodium bicarbonate ($NaHCO_3$) bath, and then through a water bath. The sodium bicarbonate in this case was used at the rate of one pound to 100 gallons of water. When bases were used as solvents, followed by neutralization, the fruit was passed through either a weak acid solution (.25% HCl) or through a bath of ammonium chloride (NH_4Cl) used at the rate of one pound to 100 gallons of water. This treatment was followed by rinsing in water as before.

In order to gain information regarding the effect of moisture on the fruit at packing time, a number of lots of both apples and pears were packed at various stages of wetness following the washing treatment. Part of this fruit was stored in cold storage and part of it was stored in common storage. Some of the lots were left unwrapped, while others were put away either in common wraps or in oiled wraps. Fruit treated commercially at Medford and at Hood River also offered opportunity to gain information on this factor.

KEY TO TABLES DEALING WITH EFFECT OF CHEMICALS ON THE FRUIT

The effect of washing with hydrochloric acid—Tables XVI to XXIII inclusive.

The effect of washing with nitric acid—Tables XXIV to XXVI inclusive.

The effect of washing with sodium hydroxide—Tables XXVII to XXX inclusive.

The effect of washing with sodium chloride—Table XXXI.

The effect of washing with sodium chloride and hydrochloric acid—Table XXXII.

The effect of washing with hydrochloric and nitric acids combined—Table XXXIII.

The effect of washing with sodium thiosulfate—Table XXXIV.

The amounts of hydrochloric acid that can be safely used on apples and pears—Table XV.

The effects of temperature, concentration, and length of treatment on the fruit—Tables III to V inclusive.

TABLE III. THE EFFECT OF TEMPERATURE, CONCENTRATION, AND LENGTH OF TREATMENT: HYDROCHLORIC ACID TREATMENT YELLOW NEWTOWN APPLES (HOOD RIVER)

Temperature of solution (° F.)	⅛% HCl Injury	⅛% HCl Amount of As_2O_3 remaining (grains per lb.)	1% HCl Injury	1% HCl Amount of As_2O_3 remaining (grains per lb.)	2% HCl Injury	2% HCl Amount of As_2O_3 remaining (grains per lb.)
			½-Minute Treatment			
95	none	.0072	none	.0032	none	.0019
72	none	.0120	none	.0040	none	.0037
50	none	.0060	none	.0040	none	.0033
35	none	.0060	none	.0072	none	.0048
			1-Minute Treatment			
95	none	.0025	none	.0022	none	.0018
72	none	.0044	none	.0023	none	.0022
50	none	.0039	none	.0030	none	.0025
35	none	.0054	none	.0031	none	.0024
			5-Minute Treatment			
95	none	.0030	none	.0016	severe	.0011
72	none	.0033	none	.0026	moderate	.0015
50	none	.0036	none	.0035	slight	.0024
35	none	.0084	none	.0030	none	.0031
			10-Minute Treatment			
95	none	.0028	severe	.0014	severe	.0005
72	none	.0028	slight	.0013	moderate	.0009
50	none	.0024	slight	.0021	slight	.0012
35	none	.0025	none	.0015	slight	.0017

Untreated checks: No. 1 .0480 grains As_2O_3 per lb.
No. 2 .0610 grains As_2O_3 per lb.

TABLE IV. THE EFFECT OF TEMPERATURE, CONCENTRATION AND LENGTH OF TREATMENT: HYDROCHLORIC ACID TREATMENT ANJOU PEARS (MEDFORD)

Temperature of solution (° F.)	⅛% HCl Injury	⅛% HCl Amount of As_2O_3 remaining (grains per lb.)	1% HCl Injury	1% HCl Amount of As_2O_3 remaining (grains per lb.)	2% HCl Injury	2% HCl Amount of As_2O_3 remaining (grains per lb.)
			½-Minute Treatment			
95	none	.0039	none	.0019	none	.0016
72	none	.0052	none	.0018	none	.0025
50	none	.0065	none	.0032	none	.0017
35	none	.0048	none	.0036	none	.0017
			1-Minute Treatment			
95	none	.0029	none	.0007	none	.0010
72	none	.0033	none	.0033	none	.0021
50	none	.0031	none	.0034	none	.0020
35	none	.0035	none	.0036	none	.0056
			5-Minute Treatment			
95	none	.0017	none	.0014	slight	.0016
72	none	.0015	none	.0018	none	.0022
50	none	.0030	none	.0017	none	.0022
35	none	.0024	none	.0020	none	.0024
			10-Minute Treatment			
95	none	.0014	severe	.0012	severe	.0006
72	none	.0017	slight	.0014	slight	.0030
50	none	.0011	none	.0032	slight	.0011
35	none	.0017	none	.0016	slight	.0009

Untreated checks: No. 1 .0300 grains As_2O_3 per lb.
No. 2 .0320 grains As_2O_3 per lb.

TABLE V. THE EFFECT OF TEMPERATURE, CONCENTRATION AND LENGTH OF TREATMENT: SODIUM HYDROXIDE TREATMENT BOSC PEARS* (MEDFORD)

Temperature of solution (° F.)	⅛% NaOH — Injury	⅛% NaOH — Amount of As_2O_3 remaining (grains per lb.)	1% NaOH — Injury	1% NaOH — Amount of As_2O_3 remaining (grains per lb.)	2% NaOH — Injury	2% NaOH — Amount of As_2O_3 remaining (grains per lb.)
			½-Minute Treatment			
95	none	.0286	none	.0226	none	.0086
72	none	.0425	none	.0338	none	.0194
50	none	.0438	none	.0291	none	.0206
35	none	.0604	none	.0254	none	.0191
			1-Minute Treatment			
95	none	.0262	slight	.0066	slight	.0041
72	none	.0271	none	.0126	slight	.0074
50	none	.0214	none	.0380	none	.0182
35	none	.0341	none	.0248	none	.0158
			5-Minute Treatment			
95	slight	.0014	moderate	.0023	severe	.0022
72	slight	.0137	slight	.0046	moderate	.0031
50	slight	.0121	slight	.0054	moderate	.0092
35	none	.0121	slight	.0122	slight	.0105
			10-Minute Treatment			
95	moderate	.0102	severe	.0045	severe	.0014
72	moderate	.0129	severe	.0034	severe	.0034
50	slight	.0176	severe	.0089	severe	.0036
35	slight	.0165	severe	.0154	severe	.0027

Untreated checks: No. 1 .0915 grains As_2O_3 per lb.
No. 2 .0862 grains As_2O_3 per lb.
*These pears had received one application of Volck oil.

TABLE VI. THE EFFECT OF TEMPERATURE, CONCENTRATION AND LENGTH OF TREATMENT: HYDROCHLORIC ACID TREATMENT ANJOU PEARS (MEDFORD)

Temperature

Temperature of solution (° F.)	Amount of As_2O_3 before treatment (grains per lb.)	Amount of As_2O_3 after treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (%)
95	.0310	.0016	.0294	94.8
72	.0310	.0025	.0285	91.9
50	.0310	.0027	.0283	91.2
35	.0310	.0032	.0278	89.6

Concentration

Concentration of solution (%)	Amount of As_2O_3 before treatment (grains per lb.)	Amount of As_2O_3 after treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (%)
2	.0310	.0020	.0290	93.5
1	.0310	.0022	.0288	92.9
.33	.0310	.0030	.0280	90.3

Length of Treatment

Length of treatment (minutes)	Amount of As_2O_3 before treatment (grains per lb.)	Amount of As_2O_3 after treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (grains per lb.)	Amount of As_2O_3 removed by treatment (%)
10	.0310	.0015	.0295	95.1
5	.0310	.0019	.0291	93.8
1	.0310	.0029	.0281	90.6
½	.0310	.0032	.0278	89.6

TABLE VII. THE RELATIVE EFFICIENCY OF VARIOUS SOLVENTS

Variety	Date of picking	Date of treatment	Where grown	Spray program	Treatment	Concentration of solution %	Length of treatment (min.)	Temperature of solution ° F.	Amount of As_2O_3 (grains per lb.)
Bartlett	8/1	9/16	Medford	Calyx spray. Three cover sprays of arsenate of lead. One oil spray.	Hydrochloric acid	.33	10	60	.0030
					Nitric acid	.70	5	60	.0091
					Sodium hydroxide	.50	10	60	.0072
					Untreated	----	----	----	.0290
Comice	8/26	9/16	Medford	Calyx spray. Three cover sprays of arsenate of lead.	Hydrochloric acid	.33	10	60	.0016
					Nitric acid	.70	5	60	.0021
					Sodium hydroxide	.50	10	60	.0020
					Untreated	----	----	----	.0260
Anjou	8/25	9/16	Medford	Calyx spray. Three cover sprays of arsenate of lead.	Hydrochloric acid	.33	10	60	.0042
					Nitric acid	.70	5	60	.0048
					Sodium hydroxide	.50	10	60	.0026
					Untreated	----	----	----	.0396
Bosc	9/6	9/16	Medford	Calyx spray. Three cover sprays of arsenate of lead. One cover spray of arsenate of lead and oil.	Hydrochloric acid	.33	10	60	.0018
					Nitric acid	.70	5	60	.0038
					Sodium hydroxide	.50	10	60	.0039
					Untreated	----	----	----	.0521

TABLE VIII. THE RELATIVE EFFICIENCY OF VARIOUS SOLVENTS

Variety	Date of picking	Date of treatment	Where grown	Spray program	Treatment	Concentration of solution (%)	Length of treatment (min.)	Temperature of solution (° F.)	Amount of As_2O_3 (grains per lb.)
Winter Nelis	9/10	9/16	Medford	Calyx spray. Four cover sprays of arsenate of lead.	Hydrochloric acid	.33	10	60	.0011
					Nitric acid	.70	5	60	.0022
					Sodium hydroxide	.50	10	60	.0023
					Untreated	----	----	----	.0604
Yellow Newtown	9/17	9/17	Medford	Calyx spray. Five cover sprays of arsenate of lead and oil.	Hydrochloride acid	.33	10	60	.0072
					Nitric acid	.70	5	60	.0039
					Sodium hydroxide	.50	10	60	.0078
					Untreated	----	----	----	.1120
Yellow Newtown	9/17	9/17	Medford	Calyx spray. Five cover sprays of arsenate of lead.	Hydrochloric acid	.33	10	60	.0056
					Nitric acid	.70	5	60	.0192
					Sodium hydroxide	.50	10	60	.0076
					Untreated	----	----	----	.0982
Grimes	9/11	9/11	Corvallis	Calyx spray. Two cover sprays of arsenate of lead and lime and sulfur. One cover spray of arsenate of lead. One cover spray of arsenate of lead and bordeaux mixture.	Hydrochloric acid	.33	10	75	.0016
					Nitric acid	.70	5	75	.0018
					Sodium hydroxide	.50	10	75	.0008
					Untreated	----	----	----	.0214

DISCUSSION OF RESULTS

MECHANICAL CLEANSING

The removal of spray residue by wiping and brushing has not been entirely satisfactory. No form of mechanical cleansing thus far tested out has proved effective under all conditions. Where heavy or even moderate spray programs have been followed, a considerable amount of residue usually remains in the calyx and stem cavities and even on the

Fig. 1. The effects of wiping on the keeping quality of apples. These apples were picked from the same tree on September 9. The three specimens at the left were hand wiped, while the three at the right were left untouched. Both lots were wrapped in common fruit wraps and stored at a temperature of 66° F. and a relative humidity of 75 percent.

sides of the fruit, no matter how much care has been exercised. The roughened or russeted areas of apples and pears have been found to contain considerable residue following mechanical treatment. Mechanical cleansing devices were found to be effective only in cases where a very light spray program had been followed and where the fruit was comparatively smooth and free from wax.

Mechanical cleaning detrimental to fruit. Aside from the fact that mechanical cleaning is not altogether effective in the removal of residue, this method may result in injury to the fruit. Many of the devices in use during the past season caused more or less bruising and were responsible for a large percentage of stem punctures. Hand wiped specimens of Grimes, Yellow Newtown, Jonathan, Spitzenburg, Wagener, and Rome apples (Table XII) kept at a temperature of 66° F. and a relative humidity of 75 percent, lost from 2 to 8 percent more of their total weight than did the untreated checks of the same varieties stored under the same conditions.

The wiped apples in all cases have shown more visible wilt and have displayed signs of break-down somewhat in advance of the untreated fruit. Wiped Yellow Newtown apples turned yellow several days sooner than did the unwiped specimens from the same tree. Mechanical cleansing devices may also aid in the spread of decay organisms. This is especially true in cases where late picked or ripe fruit is being treated. Brushes and wipers may become contaminated and in turn convey the spores of such storage rots as blue mold, gray mold, anthracnose, and perennial canker to fruit which was originally free from them.

SOLVENTS ARE EFFECTIVE

The experiments on this phase of the project have revealed the fact that certain acids and bases will remove spray residue in varying degrees of effectiveness. It soon became apparent, however, that only a comparatively few compounds offered possibility from a practical standpoint, and that under no consideration can any solvent be used until an adequate storage test has shown that no injury to the fruit results from its use. Fruit which showed no ill effects immediately after treatment has often developed injury at some stage of the storage period. This has been especially true in cases where certain bases were used as solvents.

HYDROCHLORIC ACID

Removal of arsenic. Of the many compounds tested, none has proved to be superior to hydrochloric acid. When used at concentrations varying between one-fourth and two percent (actual acid), this compound has been found to be very effective in the removal of arsenical residue from both apples and pears. As will be noted from tables III to IX inclusive, from 89 to 99 percent of the arsenic was removed by the hydrochloric acid treatment. This experience has not been confined to laboratory tests alone, but has been duplicated by practical experience on a fairly large scale. Indications are that this acid will prove even more efficient when adequate washing devices are perfected.

Removal of lead. From a limited number of analyses, it appears that hydrochloric acid removes not only the arsenic from the fruit, but is also effective in the removal of the lead. Table IX, for example, shows that even when a considerable amount of lead was present before treatment, the amount remaining after treatment was so small that it could not be accurately weighed. The only instance where the lead content was fairly high after treatment was in the case of Delicious apples which had received excessive amounts of spray and which had developed a large amount of wax before treatment, the wax undoubtedly retarding the action of the acid. Even in this case, however, approximately 71 percent of the lead was removed by the treatment.

From these tests it appears that hydrochloric acid removes arsenic and lead in about equal proportion. In other words, when 95 percent of the arsenic is removed by hydrochloric acid, it can be assumed for practical purposes that 95 percent of the lead is also removed.

To determine to what extent arsenate of lead would dissolve in dilute hydrochloric acid before lead chloride would precipitate out, lead hydrogen arsenate was added in different amounts to one-percent acid at 75° F. The results showed that more than 14,400 grains of lead arsenate would dissolve in 100 gallons of one-percent hydrochloric acid before the lead chloride precipitate would form. Even if lead chloride precipitate did form, in most cases, it would be removed by agitation and mechanical action during the washing process, unless protected by the wax in the case of fully matured fruit.

Removal of copper and lime. Experiments with hydrochloric acid have shown that this compound is very efficient in removing copper and lime such as may remain on the fruit from applications of bordeaux during the season. The data given in Table X show that this acid removed all traces of copper and lime, even when these materials were on the fruit in fairly large amounts.

Effects of hydrochloric acid on the fruit. Aside from the matter of efficiency in the removal of spray residue, hydrochloric acid has proved to be practically non-injurious to the fruit (tables XVI to XXIII inclusive) when properly used. As shown in Table XIV, it does not remove the wax or protective covering. This is also indicated by the fact (Table XIII) that fruit treated with this acid does not lose weight more readily than fruit which has received no treatment. In the numerous tests made with treated and untreated fruit, no consistent differences could be detected which might indicate that the acid in any way had affected the storage or dessert quality. In all cases the treated fruit presented a clean, attractive appearance.

It must be borne in mind, however, that any solvent of sufficient strength to dissolve spray residue is apt to cause injury to the fruit if used at excessive concentrations, at too high temperatures, or for too long a time. In the case of hydrochloric acid, however, the margin of safety is sufficient to insure good results when the necessary precautions are taken. If the recommendations given in Table XV, regarding the amounts of acid to use, are adhered to, no injury should result from the hydrochloric acid treatment.

TABLE IX. THE EFFICIENCY OF HYDROCHLORIC ACID IN THE REMOVAL OF LEAD FROM APPLES AND PEARS

Variety	Date of picking	Date of treatment	Where grown	Spray program	Treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Amount of As_2O_3 (grains per lb.)	Amount of PbO (grains per lb.)
Bosc	8/21	2/8	Medford	Calyx spray. Four cover sprays of arsenate of lead.	treated	.33	10	70	.0017	trace
					untreated	----	----	----	.0680	.153
Winter Nelis	8/31	2/8	Medford	Calyx spray. Four cover sprays of arsenate of lead.	treated	.33	10	70	.0011	trace
					untreated	----	----	----	.0360	.089
Yellow Newtown	9/15	1/5	Hood River	Calyx spray. Three cover sprays of arsenate of lead.	treated	.33	10	70	.0051	trace
					untreated	----	----	----	.0310	.069
Delicious	9/14	2/8	Hood River	Calyx spray. Four cover sprays of arsenate of lead.	treated	.33	10	70	.0153	.056
					untreated	----	----	----	.0840	.196

TABLE X. THE EFFICIENCY OF HYDROCHLORIC ACID IN THE REMOVAL OF COPPER AND LIME FROM APPLES AND PEARS

Variety	Date of picking	Date of treatment	Where grown	Spray program	Treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Copper (grains per lb.)	Lime (CaO) (grains per lb.)
Yellow Newtown	9/12	9/12	Corvallis	Calyx spray. Two cover sprays of arsenate of lead and lime and sulfur. One cover spray of arsenate of lead and bordeaux mixture.	treated	.33	10	60	none	none
					untreated	----	----	----	.035	.126
Yellow Newtown	9/12	9/12	Corvallis	Calyx spray. Two cover sprays of arsenate of lead and lime and sulfur. One cover spray of arsenate of lead and bordeaux mixture.	treated	.33	10	60	none	none
					untreated	---	---	---	.023	.097
Northwestern Greening	9/12	9/12	Corvallis	Calyx spray. Two cover sprays of arsenate of lead and lime and sulfur. One cover spray of arsenate of lead and bordeaux mixture.	treated	.33	10	60	none	none
					untreated	----	----	----	.021	.074

TABLE XI. RESULTS OBTAINED WITH CUTLER CHEMICAL FRUIT WASHER

Variety.	Date of treatment.	Where grown.	Condition at time of treatment.	Spray program.	Treatment.	Length of treatment (seconds).	Concentration of solution (gallons of hydrochloric acid per 100 gallons of water).	Temperature of solution (° F.).	Pressure of acid spray (lbs.).	Amount of As_2O_3 (grains per lb.).
Stayman Winesap	1/6	Wenatchee, F. R. Gibbons	Ripe, very waxy.	Calyx spray. Four cover sprays of arsenate of lead, 2 lbs. to 100 gallons.	treated treated not treated	17 17 ----	6 6 ----	57 79 ----	13 13 ----	.0047 .0035 .0304
Yellow Newtown	1/6	Hood River, H. L. Shoemaker	Fairly ripe, waxy.	Calyx spray. Three cover sprays of arsenate of lead, 8 lbs. to 300 gallons.	treated treated not treated	17 17 ----	6 6 ----	57 79 ----	13 13 ----	.0063 .0089 .0381
Yellow Newtown	1/6	Hood River, H. M. Vannier	Fairly ripe, waxy.	Calyx spray. Four cover sprays of arsenate of lead, 4 lbs. to 100 gallons.	treated treated not treated	17 17 ----	6 6 ----	57 79 ----	13 13 ----	.0093 .0052 .0362
Yellow Newtown	1/6	Hood River, Cecil Cutler	Fairly ripe, waxy.	Calyx spray. Three cover sprays of arsenate of lead, 3 lbs. to 100 gallons.	treated treated not treated	17 17 ----	6 6 ----	57 79 ----	13 13 ----	.0043 .0033 .0343
Yellow Newtown	1/19	Hood River, H. L. Shoemaker	Fairly ripe, waxy.	Calyx spray. Three cover sprays of arsenate of lead, 8 lbs. to 300 gallons of water.	treated not treated	17 ----	6 ----	58 ----	4 ----	.0032 .0381
Stayman Winesap	1/19	Wenatchee, F. R. Gibbons	Ripe, very waxy.	Calyx spray. Four cover sprays of arsenate of lead, 2 lbs. to 100 gallons.	treated not treated	17 ----	6 ----	58 ----	4 ----	.0029 .0304

Neutralizing bath not necessary with hydrochloric acid. In the early recommendations concerning the hydrochloric acid treatment, (Oregon Circular of Information No. 11), a neutralizing bath consisting of one pound of soda to 100 gallons of water was recommended. Subsequent experiments tend to show, however, that the neutralizing bath is necessary only in case efficient rinsing cannot be done following the use of the acid. Where plenty of water is available, the neutralizing bath should not be necessary.

TABLE XII. THE EFFECT OF WIPING ON LOSS OF WEIGHT IN APPLES
Stored at 66° F. Relative humidity, 75%. Wrapped in plain wraps.

Lot No.	Variety	Date of picking	Date of treatment	Date of final weighing	Treatment	Loss of weight (%)
1	Grimes	9/9	9/9	11/7	wiped	12.1
					unwiped	6.4
2	Jonathan	9/9	9/9	11/7	wiped	15.8
					unwiped	7.7
3	Spitzenburg	9/9	9/9	11/7	wiped	11.1
					unwiped	8.0
4	Wagener	9/9	9/9	11/7	wiped	7.1
					unwiped	4.8
5	Rome Beauty	10/11	10/11	1/2	wiped	19.2
					unwiped	11.6

Other desirable characteristics of hydrochloric acid. Aside from those already considered, hydrochloric acid has other desirable characteristics that should be mentioned. First, it is a comparatively cheap chemical and can be obtained in large quantities. Second, it is effective at low temperatures, a factor of no mean importance in deciduous fruit regions. Tables III to VI inclusive, for example, show that this acid is effective even at 35° F. Third, it is a non-oxidizing compound, and therefore is not apt to cause discoloration, especially to injured tissue in stem punctures or like abraisions. Fourth, it is a volatile substance and disappears of its own accord in cases where rinsing has not been thoroughly done. This being true, there is practically no chance that in case of improper washing the acid would reach the consumer. Fifth, it is readily removed from the fruit following treatment. Sixth, it is not a disagreeable material with which to work.

Hydrochloric acid available for treatment of fruit. The commercial hydrochloric acid available for the treatment of fruit may be obtained from any wholesale dealer in heavy chemicals. The commercial product is usually called Muriatic acid and is shipped in standard-sized 12-gallon carboys. These should be labeled or marked 20° Baumé, indicating about 32 percent actual acid. To make a one-percent solution, therefore, it is necessary to use approximately 3 gallons of the commercial product to 100 gallons of water. Table XV shows the gallons of commercial acid that may be used per 100 gallons of water, depending upon the time and temperature factors. Commercial hydrochloric acid is usually brownish in color and contains certain impurities, among which is a

trace of arsenic acid. This is so small, however, that it need not be considered. The high grade hydrochloric acid generally referred to as "C. P." or chemically pure contains about 37 percent actual acid. This is also available in 12-gallon carboys but is much higher in price. It is not necessary to use this grade of acid.

Replenishing the acid bath. Since only a very small amount of the acid actually reacts with the residue, the hydrochloric acid bath loses but little of its efficiency with repeated use. A certain amount of the solution, however, is carried away by the fruit and the supply must be replenished with acid and water from time to time, while the accumulation of dirt and debris makes it necessary to change the bath once in a while. This, however, depends largely upon the type of equipment used and the conditions under which the work is being done.

Tests over a 16-hour period, where about 1000 boxes of apples were put through the same bath, showed practically no decrease in the concentration of the acid when the above additions were made as required.

OTHER ACIDS LESS DESIRABLE

Other acids such as nitric, acetic, and sulfuric, while promising in some respects, have proved to be generally inferior to hydrochloric acid. Nitric acid is quite efficient in the removal of spray residue and when properly used does not injure the fruit. This acid, however, is considerably higher in price and is less desirable for the reasons that it is an oxidizing substance and that it is less volatile than hydrochloric acid. Acetic acid has proved to be inefficient except when used at high concentrations; in some cases it causes considerable injury. Sulfuric acid seems to remove the residue fairly well but like acetic acid is apt to cause injury.

BASES OR "ALKALIES"

Although bases in general tend to remove spray residue, sodium hydroxide (caustic soda) is the only basic compound employed in the course of these studies that successfully removes arsenate of lead under all conditions. Although this compound offers some possibilities, it has generally proved to be inferior to hydrochloric acid.

Efficiency of sodium hydroxide. When used at ordinary temperatures and at the same concentrations, sodium hydroxide has been no more efficient than hydrochloric acid. In fact, a summary of all the analyses made on fruit treated with both compounds shows hydrochloric acid to have been a little more effective. At temperatures above 100° F., sodium hydroxide might prove to be somewhat more effective.

Effect of sodium hydroxide on the fruit. The use of sodium hydroxide has resulted in more injury to the fruit than has hydrochloric acid (tables XXVII to XXX inclusive). Checking and pitting of the skin has been common in fruit treated with this substance, especially that treated immediately after picking. When sodium hydroxide has been used to dissolve the spray residue, the solution soon becomes colored, indicating a solvent or penetrating action on the thin coating of wax,

and then reaction with exposed organic tissue and coloring matter. Chemical analyses (Table XIV) as well as microscopic examinations show that a considerable amount of wax is removed from the fruit when sodium hydroxide has been used. This is apt to result in wilting during

Fig. 2. The effects of sodium hydroxide on the keeping quality of apples. The lower six specimens were treated with one-half percent sodium hydroxide for ten minutes. The upper six specimens were untreated. Both lots were picked from the same tree on September 9, and were kept in common storage at a temperature of 66° F. and a relative humidity of 75 percent.

the storage period. Pears treated with this compound frequently show darkening around the lenticels, especially on the colored or "blushed" areas. This condition usually develops during the storage period. In russet varieties the russeting is frequently darker after treatment. Bosc

pears treated with sodium hydroxide have shown a slight tendency to scald sooner in storage than have the untreated checks of the same variety. Apples washed with this compound frequently show a considerable amount of dark residue in the calyx cavity. This is probably due to decomposition of wax and other organic matter dissolved by the solvent.

TABLE XIII. THE RELATIVE EFFECT OF WIPING AND WASHING ON LOSS OF WEIGHT IN APPLES
Stored at 66° F. Relative humidity, 75%. Wrapped in plain wraps.

Lot No.	Variety	Date of picking	Date of treatment	Treatment	Date of final weighing	Loss of weight (%)
1	Yellow Newtown	9/29	9/29	Untreated	11/7	4.4
2	Yellow Newtown	9/29	9/29	Dipped for 10 minutes in .33 percent hydrochloric acid	11/7	4.6
3	Yellow Newtown	9/29	9/29	Hand wiped	11/7	6.1

TABLE XIV. THE RELATIVE AMOUNTS OF WAX REMOVED BY HYDROCHLORIC ACID AND SODIUM HYDROXIDE

Variety.	Date of picking.	Date of treatment.	Number of specimens.	Treatment.	Concentration of solution (%).	Length of treatment (minutes).	Temperature of solution (° F.).	Amount of wax after treatment (grains per lb.).
Anjou	8/21	1/5	6	not treated	.....	....	....	,213
			6	hydrochloric acid	1.00	4	70	.226
			6	sodium hydroxide	1.00	4	70	.151
Comice	8/26	1/5	6	not treated	.....	....	....	.328
			6	hydrochloric acid	1.00	4	70	.284
			6	sodium hydroxide	1.00	4	70	.265
Yellow Newtown	9/15	1/5	6	not treated	.....	....	....	1.209
			6	hydrochloric acid	.33	10	70	1.275
			6	sodium hydroxide	.33	10	70	1.161

Sodium hydroxide does not remove bordeaux. Again, sodium hydroxide is less desirable than hydrochloric acid for the reason that it removes only certain forms of spray residue. It does not effectively remove copper and lime such as are used in bordeaux sprays. Sodium hydroxide, in fact, changes any copper that may be water soluble to a more insoluble state. Figure 4 shows the relative solubility of bordeaux mixture in sodium hydroxide and in hydrochloric acid.

Sodium hydroxide adheres to the fruit. Sodium hydroxide has a tendency to adhere to the fruit, thus making the problem of rinsing rather difficult. It cannot be washed off completely with water alone at ordinary temperatures unless unusual pains are taken. In this connection, it should be remembered that sodium hydroxide is non-volatile and will remain on the fruit indefinitely unless thoroughly washed off. To

Fig. 3. Darkening around the lenticels caused by sodium hydroxide.

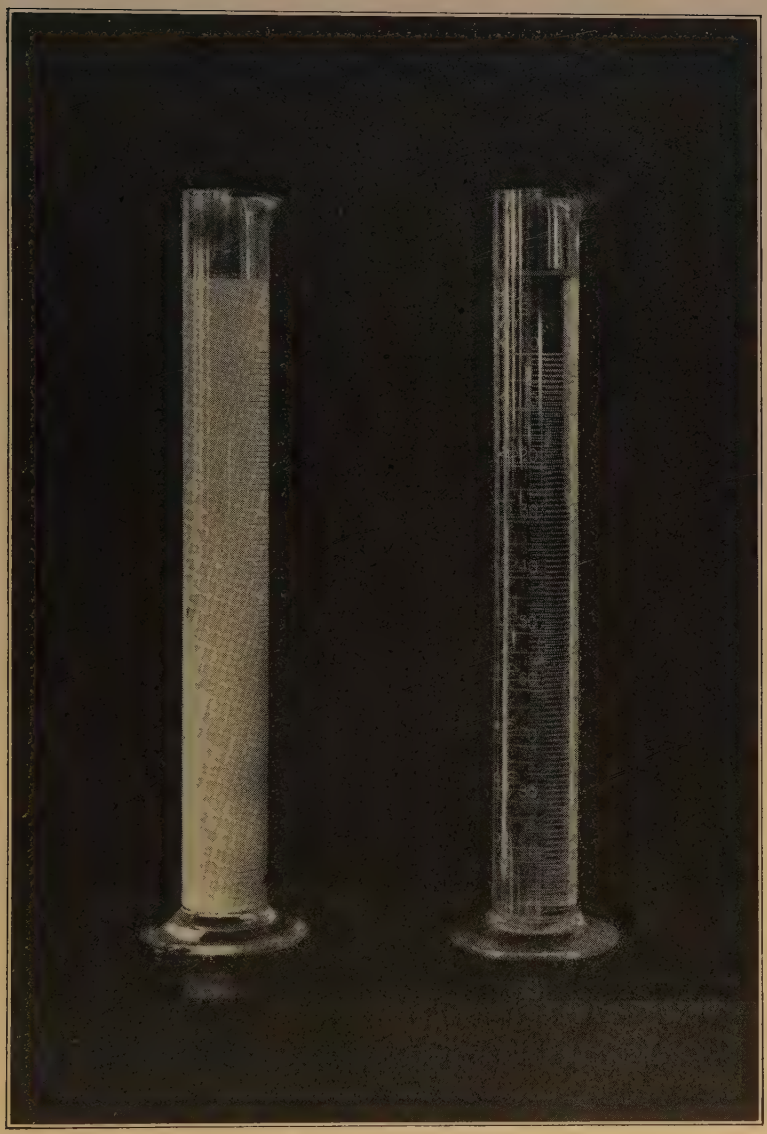

Fig. 4. The dissoluble effects of hydrochloric acid and sodium hydroxide on bordeaux. The cylinder to the left was filled with one-percent sodium hydroxide, while the cylinder to the right was filled with one-percent hydrochloric acid. An equal amount of bordeaux was then added to each cylinder. As indicated, the bordeaux dissolved immediately in the hydrochloric acid, leaving a clear solution, while no noticeable change occurred when the bordeaux was added to the sodium hydroxide.

remove it effectively and completely from the fruit, a neutralizing bath would probably have to be used. This would necessitate the use of an acid or some compound such as ammonium chloride.

FACTORS AFFECTING THE EFFICIENCY OF SOLVENTS

The efficiency or the rate at which solvents remove spray residue may be affected by several factors. Tables III to VI inclusive, for example, show that the amount of solvent action taking place is affected by (1) the length of time that the fruit is subjected to treatment, (2) the concentration of the solution, and (3) the temperature of the solution. A study of these data, however, shows that efficiency is not directly proportional to length of treatment, concentration and temperature. Doubling the length of treatment, for example, does not necessarily double the efficiency. A summation of these data shows, in fact, that approximately 90 percent of all the residue was removed during the first half minute of treatment (Fig. 5), and that only 5 percent more residue was removed when the length of treatment was increased to ten minutes. Temperature and concentration affect efficiency in about the same way. The difference in efficiency between a .33-percent solution and 1-percent solution is very much more pronounced than that between a 1-percent and a 2-percent solution.

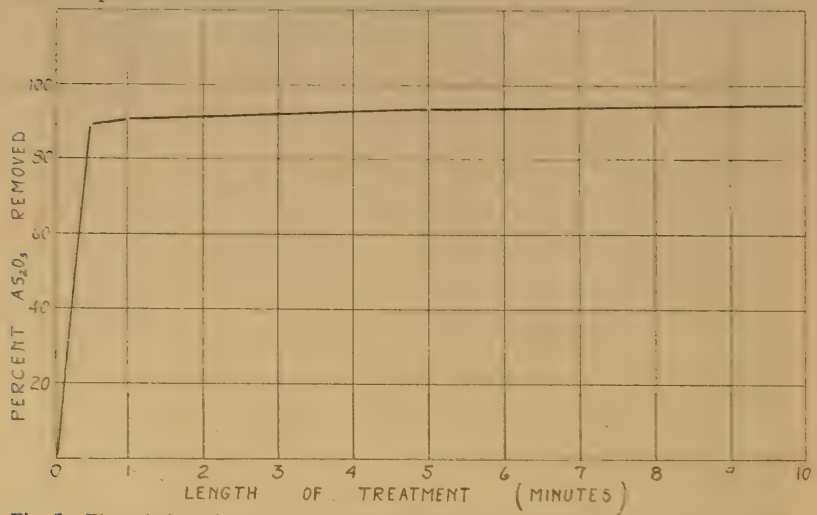

Fig. 5. The relation of length of treatment to efficiency in the removal of spray residue by solvents.

Maturity of the fruit. The efficiency of solvents is also associated with the degree of maturity attained by the fruit at the time of treatment. Apples at picking time respond much more readily to treatment than they do later on when wax development has taken place. In the case of very waxy fruit that had received heavy applications of spray, some difficulty was experienced in bringing the residue content down to an acceptable amount. This is undoubtedly due to the fact that wax

forms a protective coating over the residue and retards or prevents chemical action. This being true, it appears highly desirable and probably necessary that cleansing of the fruit be done as soon after picking as possible.

Agitation. Of all the factors that affect the efficiency of solvents, probably no factor is of greater importance than agitation of the solution while the fruit is being treated. Repeated tests have shown that in cases where no agitation was employed, a considerable period of time was necessary to remove even the visible residue, but when the solution was sprayed onto the fruit, or applied with force, the visible residue was usually removed in from 10 to 20 seconds. This difference can probably be accounted for in two ways. First, agitation removes a certain amount of residue by physical means, and, second, agitation tends to break up the thin film of reaction products that forms after contact with the residue and which retards the action of the chemicals. Agitation is also essential in removing dirt and other foreign matter from the surface of the fruit.

Table XI gives results obtained with the Cutler Chemical Fruit Washer. With this machine, the acid solution is sprayed onto the fruit. It will be observed, however, that the fruit treated in these tests was ripe and more or less covered with wax. The machine would undoubtedly be even more effective on fruit that is less mature.

Spray program followed. The amount of treatment required to clean fruit successfully is also dependent, in a large measure, upon the spray program followed. In cases where heavy deposits of residue are on the fruit, it naturally follows that more solvent action will be required to do the work.

Effect of oil sprays. The use of oil sprays along with the lead arsenate may also influence somewhat the removal of residue by solvents. It appears that oil tends to retard the action of the solvents but does not make cleaning by this method impossible, provided a sufficient amount of time elapses between the date of application of the oil and the date of treatment. Just how long this period of time needs to be cannot be answered at this time. The shortest interval between the application of the oil and the date of treatment recorded in these tests was about 30 days. This interval seems to have been sufficiently long to insure good results with hydrochloric acid. Subsequent work may show that this interval can be materially reduced.

Effect of "spreaders" and "deflocculants." It is generally known that many commercial brands of lead arsenate contain small amounts of one of several substances for the purpose of increasing the spreading, adhering, and suspension properties of the arsenical. These spreaders or deflocculants include casein, gum arabic, gum tragacanth, sugars, tannin, and other materials. It is important to know, therefore, whether these materials in any way retard the solvent action of hydrochloric acid on the removal of the arsenical residue. Accordingly, double-strength lead arsenate spray prepared from each of the various commercial brands containing the different spreaders was applied to apples and allowed to dry. Other samples of apples received double applications of

lead arsenate containing casein-lime spreader. All samples were then given the hydrochloric acid treatment for removal of the residue.

Examination of the apples after treatment showed that the lead arsenate was effectively removed in all cases. During the processing no differences could be detected that would indicate a retarding effect of the various spreaders on the solvent action of hydrochloric acid.

TABLE XV. AMOUNTS OF HYDROCHLORIC ACID THAT MAY BE USED WITH SAFETY AT VARIOUS TEMPERATURES AND FOR VARIOUS PERIODS OF TIME.

Length of immersion (minutes)	Temperature of solution (° F.)	Acid concentration (approximate percentage).	Gallons of commercial hydrochloric acid per 100 gallons of water
10	95	.27	.9
10	72	.33	1.0
10	50	.37	1.1
10	35	.40	1.2
5	95	.97	2.9
5	72	1.0	3.0
5	50	1.0	3.1
5	35	1.1	3.2
1	95	2.3	6.9
1	72	2.3	7.0
1	50	2.3	7.1
1	35	2.4	7.2
½	95	2.6	7.9
½	72	2.6	8.0
½	50	2.7	8.1
½	35	2.7	8.2
¼	95	2.8	8.9
¼	72	3.0	9.0
¼	50	3.0	9.1
¼	35	3.1	9.2

Various brands of arsenate of lead. It appears from these results that any commercial brand of arsenate of lead used as a spray can be effectively removed by the hydrochloric acid treatment. All brands used in these tests seemed to dissolve readily in dilute hydrochloric acid.

EFFECT OF NEUTRAL SALTS ON FRUITS

Neutral salts such as sodium chloride (common salt) and sodium thiosulfate (hypo) have proved to be ineffective in the removal of spray residue when used by themselves. There is some indication, however, that these may be of some value when used in combination with acids or other compounds. Consequently it is desirable to know what effect, if any, these chemicals have on the fruit. From the data given in tables XXXI and XXXIV, it appears that sodium chloride and sodium thiosulfate have no detrimental effect on apples and pears, even when used as saturated solutions. Common salt when used in combination with hydrochloric acid (Table XXXII) also proved to be non-injurious.

HYDROCHLORIC AND NITRIC ACID COMBINED

When used in combination with each other, hydrochloric and nitric acids have not proved to be more effective than have equal strengths of these acids used alone. In other words there is no indication that efficiency is increased by the combination of the two acids. So far as the fruit is concerned (Table XXXIII), no injury resulted when these acids were combined and used at proper concentrations.

PATHOLOGICAL STUDIES

Studies on the pathological phase of this problem have shown that such solvents as hydrochloric acid and sodium hydroxide have but little fungicidal value when used at the strengths recommended for the removal of spray residue. In the case of such organisms as blue and gray mold, hydrochloric acid seems to have little or no effect on the spores unless used at strengths that would harm the fruit. On the other hand, however, there is no evidence that washing with acid stimulates the growth of organisms or renders the fruit more susceptible to decay.

The question of decay in relation to the washing process has caused more or less comment and at the present time the Oregon Experiment Station is investigating the possibility of using a fungicide in connection with the solvents. More work must be done, however, before definite recommendations can be made concerning this phase of the problem.

During the past season, very little trouble from decay was encountered in the fruit treated by solvents. Practically no trouble resulted from this source with the fruit that was harvested at the proper time and treated shortly after picking. In a few cases, the washing tanks appear to have become contaminated when ripe fruit which already showed some decay was put through them. In this manner the spores of blue mold were transmitted to cuts and bruises and a certain amount of decay occurred. This fact emphasizes the necessity of treating the fruit as soon after harvest as possible. When this is done, there seems to be but little danger of infection from the washing solution.

Moisture on the fruit at packing time. Packing fruit at various stages of wetness following the washing treatment has given varying results. A small amount of moisture, in most cases, was absorbed by the paper in from 12 to 24 hours and appeared to do no harm. This was especially true of fruit that was comparatively free from decay to begin with and that was treated within a short time after picking. Even when packed with considerable moisture, this fruit usually showed no bad effects from the treatment. On the other hand, fruit treated late in the season, after more or less contamination had taken place, seemed to decay more readily when packed wet. In the many lots under observation, no physiological troubles appeared which could be directly attributed to the fact that the fruit was packed with moisture upon it. The experiments on this phase of the work are incomplete and more definite recommendations will be made at a later date.

EQUIPMENT FOR WASHING FRUIT

It is at once apparent that if the washing method is ever to be practical, equipment for its use must be developed. Fortunately, considerable progress has already been made in this direction. Several individuals and commercial firms are now working on the problem and indications are that efficient and economical washing machines will soon be available.

TABLE XVI. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Anjou	8/25	Medford	treated, 9/16	.33	10	60	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Winter Nelis	9/10	Medford	treated, 9/16	.33	10	60	none	12/28	none	none
			not treated	----	----	----	-------	12/28	-------	-------
Comice	8/26	Medford	treated, 9/16	.33	10	60	none	12/24	none	none
			not treated	----	----	----	-------	12/24	-------	-------
Bosc	9/6	Medford	treated, 9/16	.33	10	60	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Bartlett	8/1	Medford	treated, 9/16	.33	10	60	none	10/17	none	none
			not treated	----	----	----	-------	10/17	-------	-------
Arkansas Black	9/25	Corvallis	treated, 10/9	.33	10	65	none	1/29	none	none
			not treated	----	----	----	-------	1/29	-------	-------
Aikin	9/25	Corvallis	treated, 10/9	.33	10	65	none	2/10	none	none
			not treated	----	----	----	-------	2/10	-------	-------

TABLE XVII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Rinsed with water only. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Bosc	9/6	Medford	treated, 9/16	.33	10	60	none	12/25	none	none
			not treated	----	----	----	--------	12/25	--------	--------
Anjou	8/25	Medford	treated, 9/16	.33	10	60	none	12/25	none	none
			not treated	----	----	----	--------	12/25	--------	--------
Winter Nelis	9/10	Medford	treated, 9/16	.33	10	60	none	12/28	none	none
			not treated	----	----	----	--------	12/28	--------	--------
Comice	8/26	Medford	treated, 9/16	.33	10	60	none	12/24	none	none
			not treated	----	----	----	--------	12/24	--------	--------
Yellow Newtown	9/17	Medford	treated, 9/17	.33	10	60	none	1/10	none	none
			not treated	----	----	----	--------	1/10	--------	--------
Delicious	10/13	Hood River	treated, 10/19	.33	10	60	none	1/5	none	none
			not treated	----	----	----	--------	1/5	--------	--------
Yellow Newtown	10/13	Hood River	treated, 10/19	.33	10	60	none	1/15	none	none
			not treated	----	----	----	--------	1/15	--------	--------

TABLE XVIII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Rinsed with water only. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Black Twig	9/25	Corvallis	treated, 10/9	.33	10	65	none	2/10	none	none
			not treated	----	----	----	--------	2/10	--------	--------
Red Cheek Pippin	10/9	Corvallis	treated, 10/9	.33	10	65	none	2/8	none	none
			not treated	----	----	----	--------	2/8	--------	--------
Aikin	9/25	Corvallis	treated, 10/9	.33	10	65	none	2/10	none	none
			not treated	----	----	----	--------	2/10	--------	--------
Arkansas Black	9/25	Corvallis	treated, 10/9	.33	10	65	none	2/15	none	none
			not treated	----	----	----	--------	2/15	--------	--------
Northwestern Greening	9/25	Corvallis	treated, 10/9	.33	10	65	none	2/10	none	none
			not treated	----	----	----	--------	2/10	--------	--------
Winesap	10/15	Wenatchee	treated, 11/8	.33	10	60	none	2/15	none	none
			not treated	----	----	----	--------	2/15	--------	--------
Stayman Winesap	10/15	Wenatchee	treated, 11/8	.33	10	60	none	2/10	none	none
			not treated	----	----	----	--------	2/10	--------	--------

TABLE XIX. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Jonathan	8/17	Medford	8/17	.5	10	70	none	1/5	none	none
Winesap	8/17	Medford	8/17	.5	10	70	none	1/10	none	none
Banana	8/17	Medford	8/17	.5	10	70	none	1/5	none	none
Newtown	8/17	Medford	8/17	.5	10	70	none	1/10	none	none
Bartlett	8/17	Medford	8/17	.5	10	70	none	10/1	none	none
Winter Nelis	8/17	Medford	8/17	.5	10	70	none	1/4	none	none
Anjou	8/17	Medford	8/17	.5	10	70	none	1/5	none	none
Bosc	8/17	Medford	8/17	.5	10	70	none	1/5	none	none
Comice	8/17	Medford	8/17	.5	10	70	none	1/5	none	none
Comice	8/23	Medford	8/23	1.0	10	84	none	1/5	none	none
Bosc	8/23	Medford	8/23	1.0	10	84	none	1/4	none	none
Anjou	8/23	Medford	8/23	1.0	10	84	slight burning	1/4	none	slight shriveling
Bartlett	8/23	Medford	8/23	1.0	10	84	none	9/20	none	none
Newtown	8/23	Medford	8/23	1.0	10	84	slight burning	1/5	none	slight-shriveling

TABLE XX. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS.
Hydrochloric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Bartlett	8/24	Medford	treated, 8/24	1.0	10	84	none	8/31	none	none
			not treated	-----	---	---	-------	8/31	-------	-------
Comice	8/23	Medford	treated, 8/23	1.0	10	84	none	9/10	none	none
			not treated	-----	---	---	-------	9/10	-------	-------
Bosc	8/23	Medford	treated, 8/23	1.0	10	84	none	9/4	none	none
			not treated	-----	---	---	-------	9/4	-------	-------
Yellow Newtown	8/23	Medford	treated, 8/23	1.0	10	84	none	10/5	none	none
			not treated	-----	---	---	-------	10/5	-------	-------
Delicious	9/14	Hood River	treated, 9/19	.33	10	70	none	10/12	none	none
			not treated	-----	---	---	-------	10/12	-------	-------
Ortley	9/14	Hood River	treated, 9/19	.33	10	70	none	10/20	none	none
			not treated	-----	---	---	-------	10/20	-------	-------
Rhode Island Greening	9/20	Corvallis	treated, 10/9	.33	10	70	none	10/25	none	none
			not treated	-----	---	---	-------	10/25	-------	-------

TABLE XXI. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Bartlett	8/17	Medford	treated, 8/17	.5	10	70	none	8/30	none	none
			not treated	-----	----	----	--------	8/30	--------	--------
Comice	8/17	Medford	treated, 8/17	.5	10	70	none	9/5	none	none
			not treated	-----	----	----	--------	9/5	--------	--------
Bosc	8/18	Medford	treated, 8/18	.25	10	75	none	9/3	none	none
			not treated	-----	----	----	--------	9/3	--------	--------
Comice	8/18	Medford	treated, 8/18	.25	10	75	none	9/4	none	none
			not treated	-----	----	----	--------	9/4	--------	--------
Winter Nelis	8/18	Medford	treated, 8/18	.25	10	75	none	9/6	none	none
			not treated	-----	----	----	--------	9/6	--------	--------
Yellow Newtown	8/18	Medford	treated, 8/18	.25	10	75	none	10/5	none	none
			not treated	-----	----	----	--------	10/5	--------	--------
Anjou	8/23	Medford	treated, 8/23	1.0	10	84	slight burning	9/8	none	slight discoloration
			not treated	-----	----	----	--------	9/8	--------	--------

TABLE XXII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS.
Hydrochloric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Winter Banana	8/17	Medford	treated, 8/17	.5	10	70	none	9/14	none	none
			not treated	----	----	----	-------	9/14	-------	-------
Jonathan	8/17	Medford	treated, 8/17	.5	10	70	none	9/9	none	none
			not treated	----	----	----	-------	9/9	-------	-------
Yellow Newtown	8/17	Medford	treated, 8/17	.5	10	70	none	11/5	none	none
			not treated	----	----	----	-------	11/5	-------	-------
Winesap	8/17	Medford	treated, 8/17	.5	10	70	none	10/17	none	none
			not treated	----	----	----	-------	10/17	-------	-------
Winter Nelis	8/17	Medford	treated, 8/17	.5	10	70	none	9/5	none	none
			not treated	----	----	----	-------	9/5	-------	-------
Bosc	8/17	Medford	treated, 8/17	.5	10	70	none	9/3	none	none
			not treated	----	----	----	-------	9/3	-------	-------
Anjou	8/17	Medford	treated, 8/17	.5	10	70	none	9/4	none	none
			not treated	----	----	----	-------	9/4	-------	-------

TABLE XXIII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric acid treatment. Rinsed with water only. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Golden Delicious	9/20	Corvallis	treated, 10/19	.33	10	75	none	10/15	none	none
			not treated	—	—	—	———	10/15	———	———
Rome	9/21	Corvallis	treated, 10/19	.33	10	75	none	10/20	none	none
			not treated	—	—	—	———	10/20	———	———
Yellow Newtown	9/21	Corvallis	treated, 10/19	.33	10	75	none	11/5	none	none
			not treated	—	—	—	———	11/5	———	———

TABLE XXIV. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Nitric acid treatment. Rinsed with water only. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Bartlett	8/1	Medford	treated, 9/15	.70	5	60	none	10/17	none	none
			not treated	—	—	—	———	10/17	———	———
Anjou	8/25	Medford	treated, 9/16	.70	5	60	none	12/25	none	none
			not treated	—	—	—	———	12/25	———	———
Yellow Newtown	9/17	Medford	treated, 9/17	.35	10	60	none	1/10	none	none
			not treated	—	—	—	———	1/10	———	———
Grimes	9/12	Corvallis	treated, 9/12	.70	5	75	none	12/30	none	none
			not treated	—	—	—	———	12/30	———	———
Jonathan	9/12	Corvallis	treated, 9/12	.70	5	75	none	12/30	none	none
			not treated	—	—	—	———	12/30	———	———
Yellow Newtown	9/12	Corvallis	treated, 9/12	.70	5	75	none	1/10	none	none
			not treated	—	—	—	———	1/10	———	———

TABLE XXV. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS.
Nitric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Bartlett	8/1	Medford	treated, 9/16	.70	5	60	none	10/17	none	none
			not treated	----	----	----	-------	10/17	-------	-------
Comice	8/26	Medford	treated, 9/16	.70	5	60	none	12/24	none	none
			not treated	----	----	----	-------	12/24	-------	-------
Winter Nelis	9/10	Medford	treated, 9/16	.70	5	60	none	12/28	none	none
			not treated	----	----	----	-------	12/28	-------	-------
Anjou	8/25	Medford	treated, 9/16	.70	5	60	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Bosc	9/6	Medford	treated, 9/16	.70	5	60	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Grimes	9/12	Corvallis	treated, 9/12	.70	5	75	none	12/30	none	none
			not treated	----	----	----	-------	12/30	-------	-------
Yellow Newtown	9/17	Medford	treated, 9/17	.70	5	60	none	1/10	none	none
			not treated	----	----	----	-------	1/10	-------	-------

TABLE XXVI. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS.
Nitric acid treatment. Neutralized with sodium bicarbonate. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Jonathan	9/12	Corvallis	treated, 9/12	.7	5	75	none	10/12	none	none
			not treated	----	----	----	--------	10/12	--------	--------
Grimes	9/12	Corvallis	treated, 9/12	.7	5	75	none	10/12	none	none
			not treated	----	----	----	--------	10/12	--------	--------
Yellow Newtown	9/12	Corvallis	treated, 9/12	.7	5	75	none	11/6	none	none
			not treated	----	----	----	--------	11/6	--------	--------
Grimes	9/12	Corvallis	treated, 9/12	.7	10	75	none	10/12	none	none
			not treated	----	----	----	--------	10/12	--------	--------
Jonathan	9/12	Corvallis	treated, 9/12	.7	10	75	none	10/12	none	none
			not treated	----	----	----	--------	10/12	--------	--------
Yellow Newtown	9/12	Corvallis	treated, 9/12	.7	10	75	slight burning	11/6	none	darkened and shriveled
			not treated	----	----	----	--------	11/6	--------	--------
Spitzenburg	9/12	Corvallis	treated, 9/12	.7	10	75	slight burning	10/12	none	darkened and shriveled
			not treated	----	----	----	--------	10/12	--------	--------

TABLE XXVII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Sodium hydroxide treatment. Rinsed with water only. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Anjou	8/25	Medford	treated, 9/16	.5	10	60	none	12/25	none	occasional dark spots
			not treated	....	....	....	.....	12/25	.....	.....
								12/25	none	russet darkened; scalded
Bosc	9/6	Medford	treated, 9/16	.5	10	60	none			
			not treated	....	....	....	.....	12/25	.....	.....
Winter Nelis	9/10	Medford	treated, 9/16	.5	10	60	none	12/28	none	russet darkened
			not treated	....	....	....	.....	12/28	.....	.....
Bartlett	8/1	Medford	treated, 9/16	.5	10	60	none	10/17	none	darkened around lenticels
			not treated	....	....	....	.....	10/17	.....	.....
Grimes	9/11	Corvallis	treated, 9/11	1.0	10	75	considerable pitting	12/30	none	somewhat shriveled
			not treated	....	....	....	.....	12/30	.....	.....

TABLE XXVIII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Sodium hydroxide treatment. Neutralized with hydrochloric acid. Rinsed with water. Stored at 32° F. Ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Comice	8/26	Medford	treated, 9/16	.50	10	60	none	12/24	none	none
			not treated	----	----	----	--------	12/24	--------	--------
Bosc	9/6	Medford	treated, 9/16	.50	10	60	none	12/25	none	russet darkened
			not treated	----	----	----	--------	12/25	--------	--------
Bartlett	8/1	Medford	treated, 9/16	.50	10	60	none	9/16	none	darkened around lenticels
			not treated	----	----	----	--------	9/17	--------	--------
Anjou	8/25	Medford	treated, 9/16	.50	10	60	none	12/25	none	occasional pitting
			not treated	----	----	----	--------	12/25	--------	--------
Winter Nelis	9/10	Medford	treated, 9/16	.50	10	60	none	12/28	none	russet darkened
			not treated	----	----	----	--------	12/28	--------	--------
Yellow Newtown	9/17	Medford	treated, 9/17	.50	10	60	none	1/10	none	none
			not treated	----	----	----	--------	1/10	--------	--------
Grimes	9/12	Corvallis	treated, 9/12	.50	10	60	occasional pitting	12/30	none	slightly shriveled
			not treated	----	----	----	--------	12/30	--------	--------

TABLE XXIX. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS
Sodium hydroxide treatment. Neutralized with hydrochloric acid. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Grimes	9/11	Corvallis	treated, 9/11	1	10	75	severe pitting	10/12	none	wilted
			not treated	----	----	----	----	10/12	----	----
Jonathan	9/11	Corvallis	treated, 9/11	1	5	75	slight pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....
Spitzenburg	9/11	Corvallis	treated, 9/11	1	5	75	slight pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....
Grimes	9/11	Corvallis	treated, 9/11	.5	10	75	slight pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....

TABLE XXX. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS
Sodium hydroxide treatment. Rinsed with water only. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Grimes	9/12	Corvallis	treated, 9/12	1	10	75	severe pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....
Jonathan	9/12	Corvallis	treated, 9/12	1	5	75	slight pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....
Grimes	9/12	Corvallis	treated, 9/12	1	5	75	slight pitting	10/12	none	wilted
			not treated	....	....	....	.....	10/12	.....	.....

TABLE XXXI. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS
Sodium chloride (common salt). Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Grimes	9/12	Corvallis	treated, 9/12	saturated	10	75	none	9/12	none	none
			not treated	----------	----	----	-------	9/12	-------	-------
Jonathan	9/12	Corvallis	treated, 9/12	saturated	10	75	none	9/12	none	none
			not treated	----------	----	----	-------	9/12	-------	-------
Yellow Newtown	9/12	Corvallis	treated, 9/12	saturated	10	75	none	10/6	none	none
			not treated	----------	----	----	-------	10/6	-------	-------

TABLE XXXII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS
Sodium chloride and hydrochloric acid. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution* (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Yellow Newtown	9/12	Corvallis	treated, 9/12	saturated	5	70	none	11/6	none	none
			not treated	----------	----	----	-------	11/6	-------	-------
Grimes	9/12	Corvallis	treated, 9/12	saturated	5	70	none	10/12	none	none
			not treated	----------	----	----	-------	10/12	-------	-------
Jonathan	9/12	Corvallis	treated, 9/12	saturated	5	70	none	10/12	none	none
			not treated	----------	----	----	-------	10/12	-------	-------

*Hydrochloric acid was used at the rate of one gallon to 100 gallons of solution.

TABLE XXXIII. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Hydrochloric and nitric acid. Neutralized with sodium bicarbonate. Rinsed with water. Stored and ripened at 66° F.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Spitzenburg	9/12	Corvallis	treated, 9/12	.70	5	75	none	10/12	none	none
			not treated	----	----	----	-------	10/12	-------	-------
Grimes	9/12	Corvallis	treated, 9/12	.70	5	75	none	10/12	none	none
			not treated	----	----	----	-------	10/12	-------	-------
Wagener	9/12	Corvallis	treated, 9/12	.70	5	75	none	10/10	none	none
			not treated	----	----	----	-------	10/10	-------	-------
Jonathan	10/12	Corvallis	treated, 9/12	.70	5	75	none	10/12	none	none
			not treated	----	----	----	-------	10/12	-------	-------

TABLE XXXIV. THE EFFECT OF WASHING ON THE STORAGE QUALITY OF APPLES AND PEARS

Sodium thiosulfate treatment. Rinsed with water only.

Variety	Date of picking	Where grown	Lots; date of treatment	Concentration of solution (%)	Length of treatment (minutes)	Temperature of solution (° F.)	Immediate effect of treatment	Date of Prime condition	Effect of treatment on Dessert quality	Effect of treatment on appearance
Stored and ripened at 66° F.										
Bosc	8/27	Medford	treated, 8/27	8	10	70	none	9/9	none	none
			not treated	----	----	----	-------	9/9	-------	-------
Comice	8/27	Medford	treated, 8/27	8	10	70	none	9/14	none	none
			not treated	----	----	----	-------	9/14	-------	-------
Yellow Newtown	8/27	Medford	treated, 8/27	8	10	70	none	11/15	none	none
			not treated	----	----	----	-------	11/15	-------	-------
Stored at 32° F. Ripened at 66°										
Bosc	8/27	Medford	treated, 8/27	8	10	70	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Comice	8/27	Medford	treated, 8/27	8	10	70	none	12/25	none	none
			not treated	----	----	----	-------	12/25	-------	-------
Yellow Newtown	8/27	Medford	not treated	----	10	70	none	1/15	none	none
			treated, 8/27	8	----	----	-------	1/15	-------	-------